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Bonk et al.

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(54) **SEAT POSITION SENSING AND ADJUSTMENT**

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(51) **Int. Cl.**

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B60R 21/015	(2006.01)
B60N 2/02	(2006.01)
B60N 2/06	(2006.01)
B60N 2/22	(2006.01)

(52) **U.S. Cl.**
CPC ***B60N 2/0252*** (2013.01); ***B60N 2/06*** (2013.01); ***B60N 2/22*** (2013.01); *B60N 2002/0272* (2013.01)

(58) **Field of Classification Search**
CPC B60N 2/0252; B60N 2/22; B60N 2/06
USPC 297/217.2, 313, 314, 344.1–344.17, 297/354.1, 354.12
See application file for complete search history.

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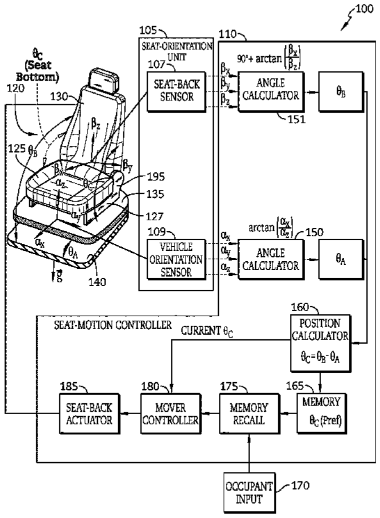
(57) **ABSTRACT**

A vehicle seat includes a seat foundation coupled to a floor of a vehicle, a seat bottom coupled to the seat foundation to move back and forth along a longitudinal axis relative to the floor, and a seat back coupled to the seat bottom to extend upwardly away from the seat bottom. The seat back pivots about an axis relative to the seat bottom.

18 Claims, 9 Drawing Sheets



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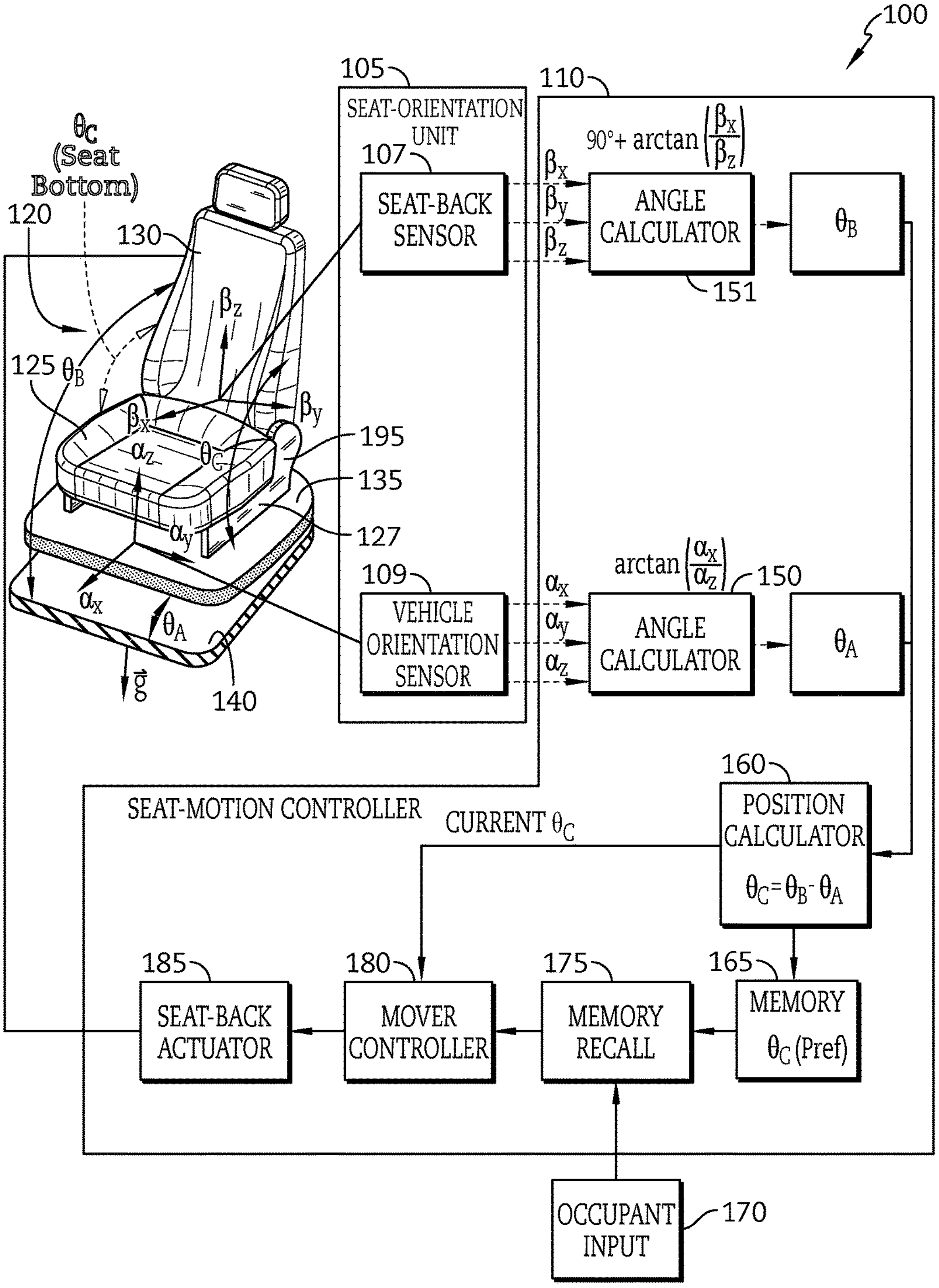

100
105
SEAT-ORIENTATION UNIT
107
SEAT-BACK SENSOR
109
VEHICLE ORIENTATION SENSOR
110
$90° + \arctan\left(\frac{\beta_x}{\beta_z}\right)$
β_x
β_y
β_z
ANGLE CALCULATOR
151
θ_B
$\arctan\left(\frac{\alpha_x}{\alpha_z}\right)$
150
α_x
α_y
α_z
ANGLE CALCULATOR
θ_A
θ_C (Seat Bottom)
120
130
125 θ_B
β_z
β_x
β_y
α_z
θ_C
195
135
127
α_y
α_x
θ_A
$\vec{g}$
140
SEAT-MOTION CONTROLLER
CURRENT θ_C
160
POSITION CALCULATOR
$\theta_C = \theta_B - \theta_A$
185
SEAT-BACK ACTUATOR
180
MOVER CONTROLLER
175
MEMORY RECALL
165
MEMORY
θ_C (Pref)
OCCUPANT INPUT
170

FIG. 1

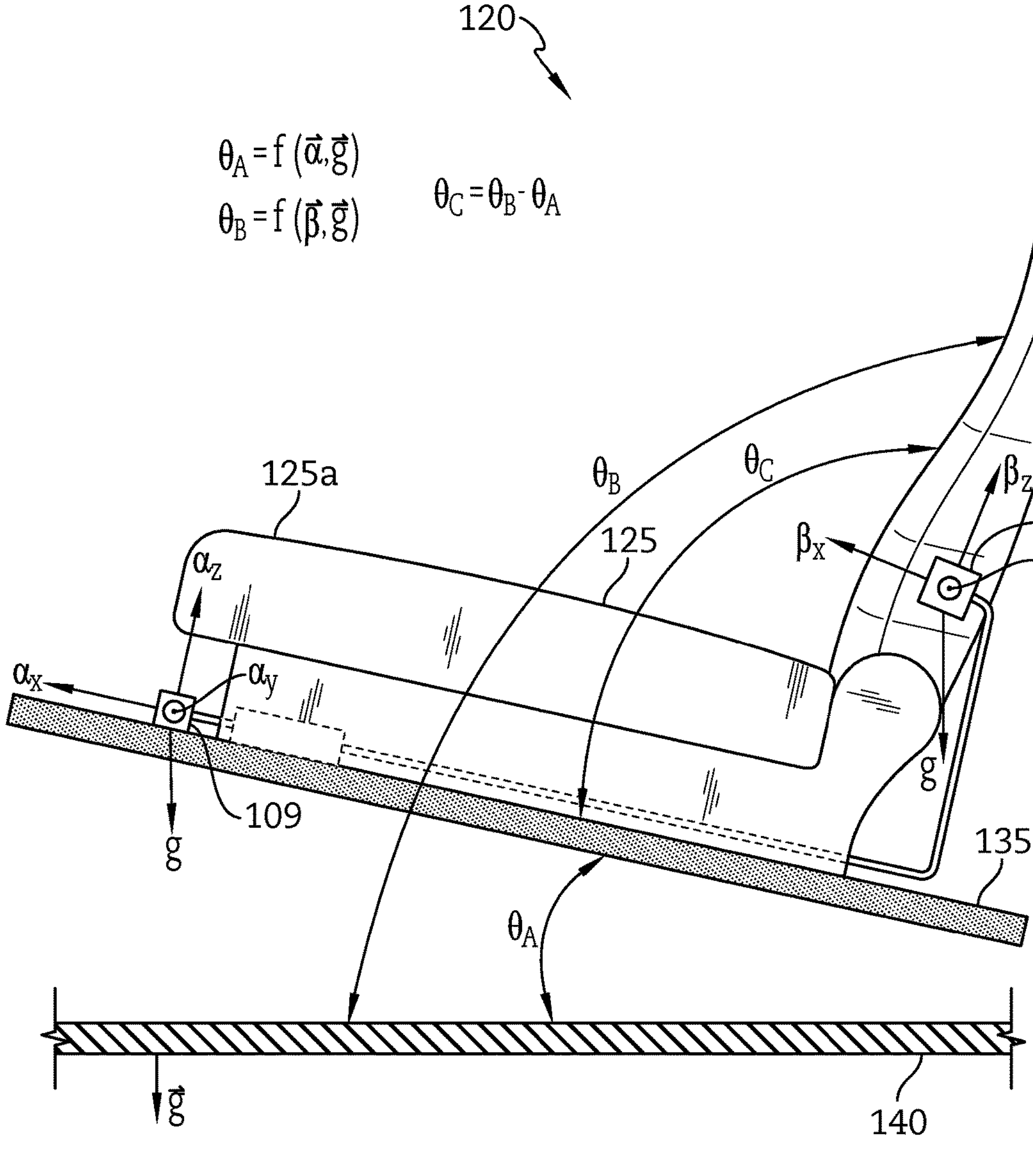
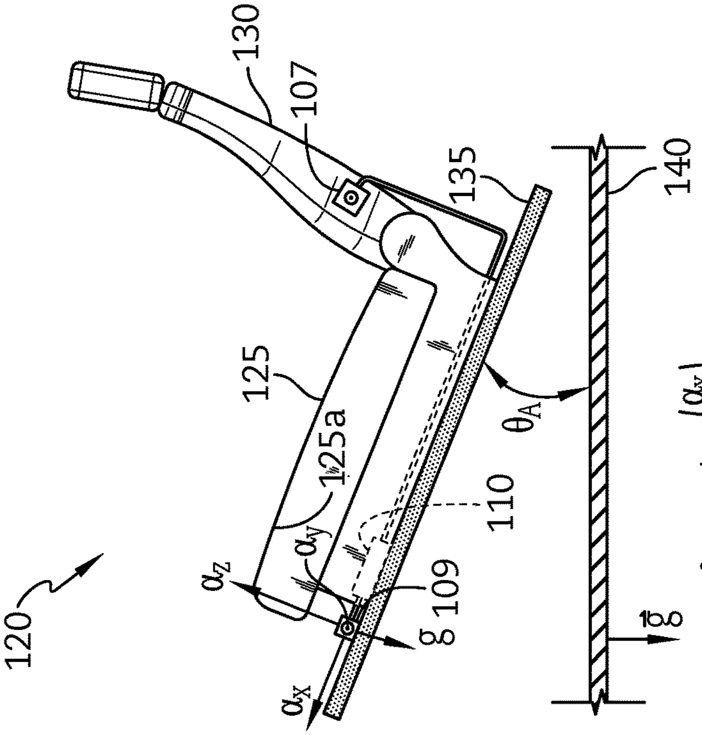
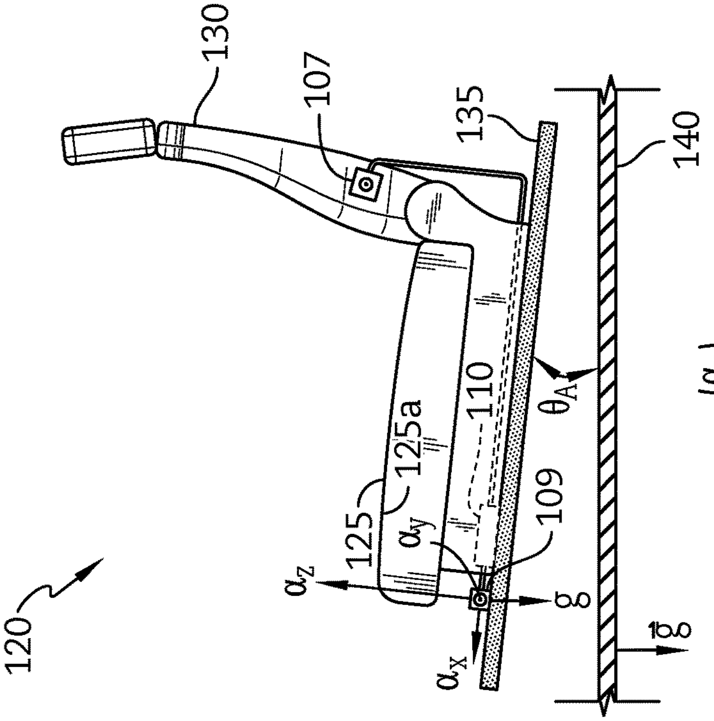

120
$\theta_A = f(\vec{\alpha}, \vec{g})$
$\theta_B = f(\vec{\beta}, \vec{g})$
$\theta_C = \theta_B - \theta_A$
130
125a
θ_B
θ_C
125
β_z
107
β_x
β_y
α_z
α_x
α_y
g
109
g
135
θ_A
$\vec{g}$
140

FIG. 2



$$\theta_A = \arctan\left(\frac{\alpha_x}{\alpha_z}\right) = 45°$$

FIG. 3B



$$\theta_A = \arctan\left(\frac{\alpha_x}{\alpha_z}\right) = 20°$$

FIG. 3A

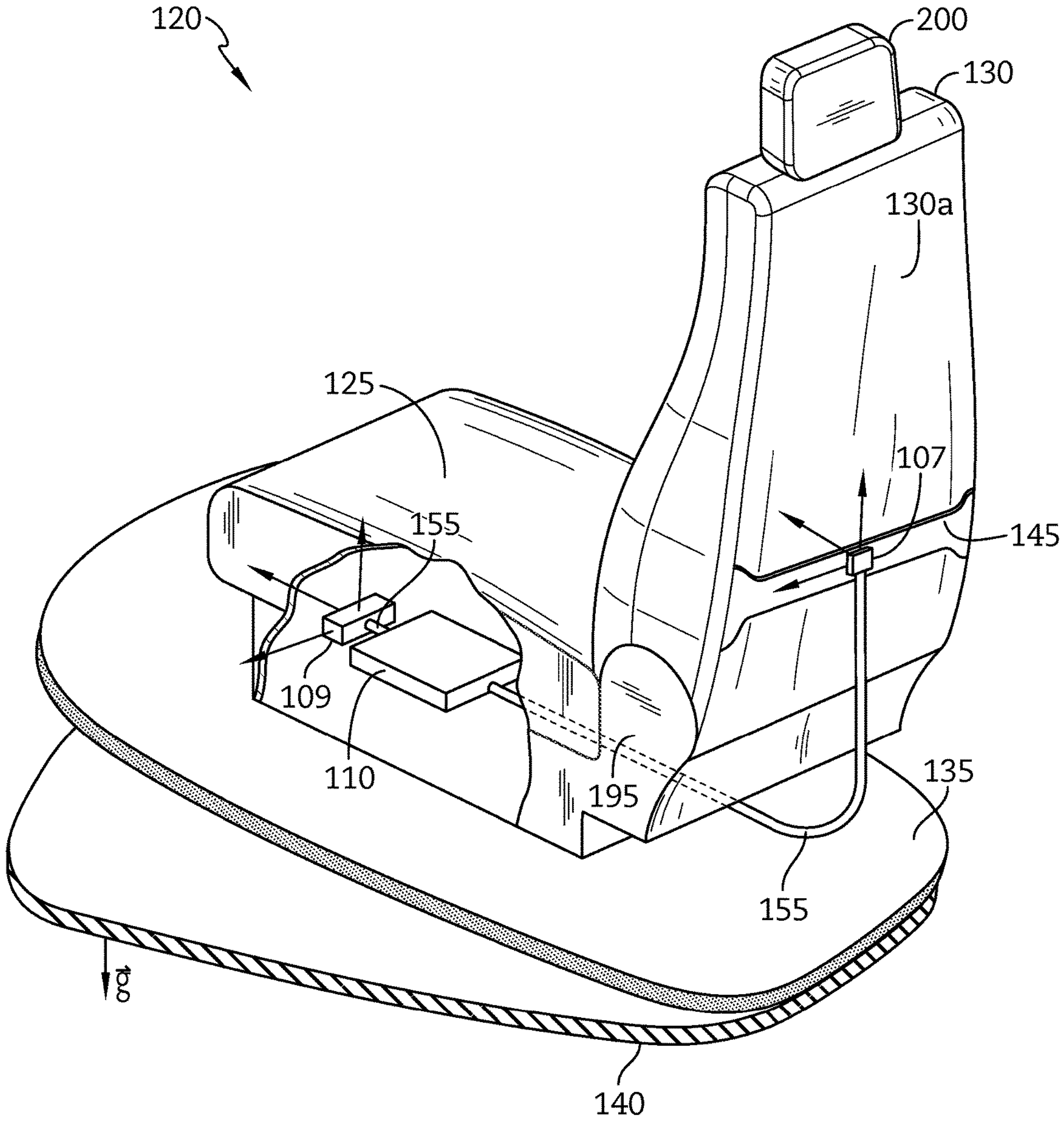


FIG. 4

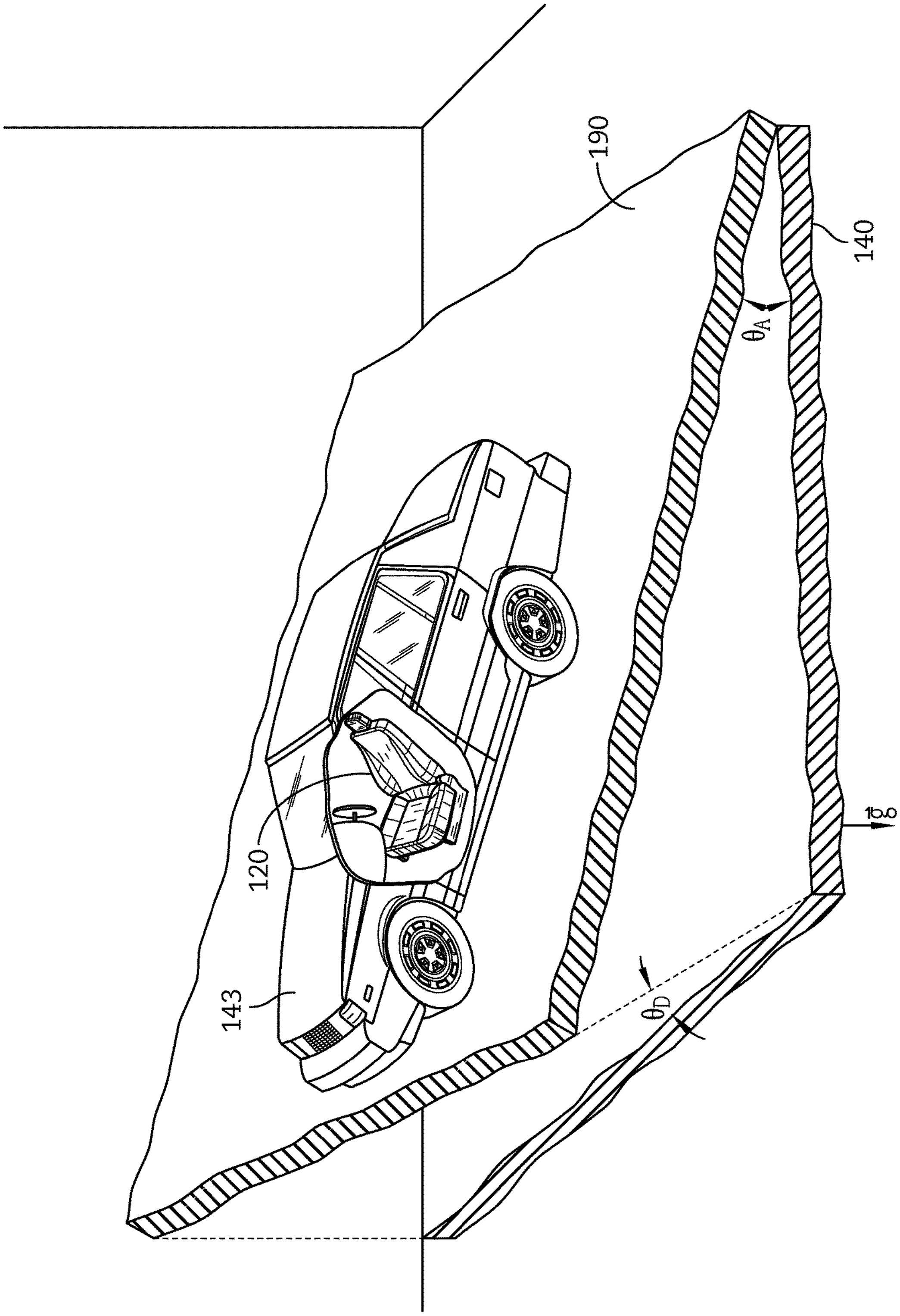
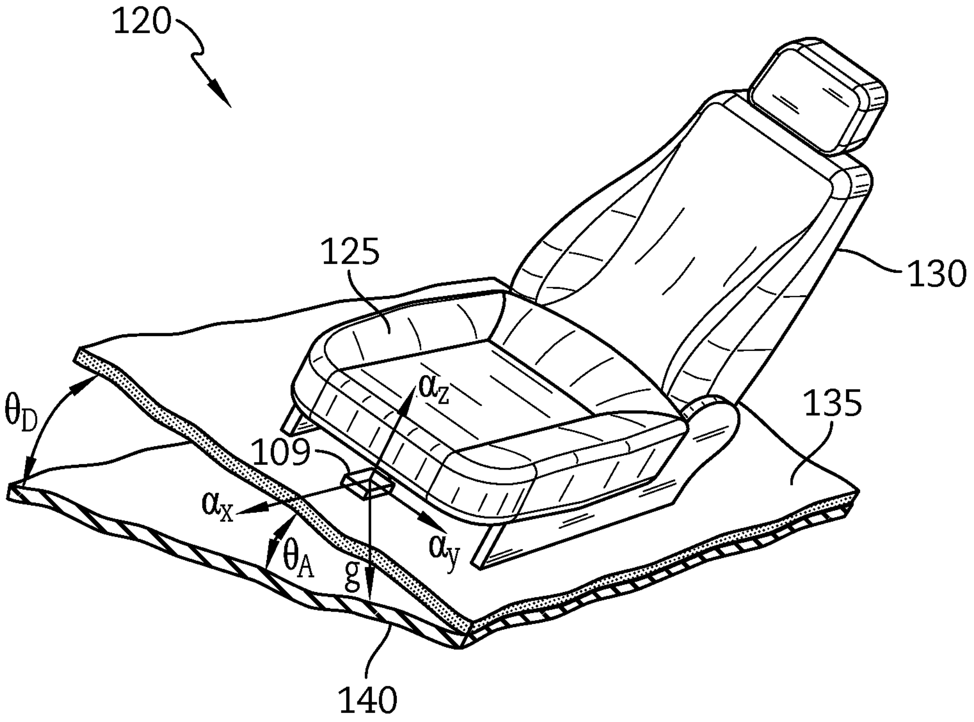


FIG. 5



$$\underline{\theta_D = 0} \qquad\qquad\qquad \underline{\theta_D > 0}$$

$$\boxed{\theta_A = \arctan\left(\frac{\alpha_x}{\alpha_z}\right)} \quad \Longleftrightarrow \quad \boxed{\theta_A = \arctan\left(\frac{\alpha_x}{\alpha_z}\right)}$$

$$\alpha_x = g \, \mathrm{Sin}\, \theta_A \qquad\qquad \alpha_x = g_A \, \mathrm{Sin}\, \theta_A$$

$$\alpha_z = g \, \mathrm{Cos}\, \theta_A \qquad\qquad \alpha_z = g_A \, \mathrm{Cos}\, \theta_A$$

$$g_A = g \, \mathrm{Cos}\, \theta_D$$

FIG. 6

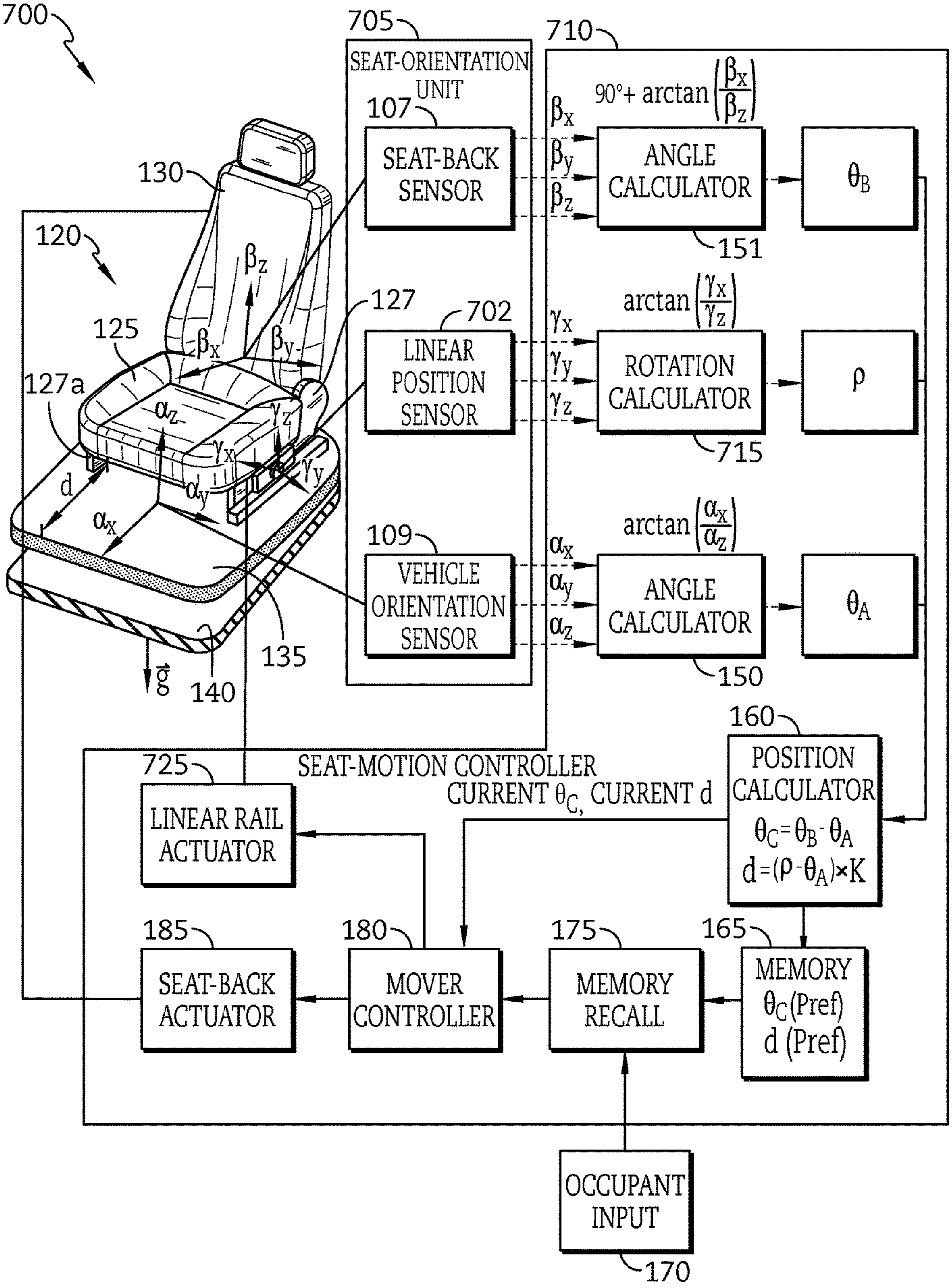

700
705
SEAT-ORIENTATION UNIT
710
107
SEAT-BACK SENSOR
β_x
β_y
β_z
$90°+\arctan\left(\frac{\beta_x}{\beta_z}\right)$
ANGLE CALCULATOR
θ_B
151
130
120
127
702
LINEAR POSITION SENSOR
γ_x
γ_y
γ_z
$\arctan\left(\frac{\gamma_x}{\gamma_z}\right)$
ROTATION CALCULATOR
ρ
715
125
127a
α_z
γ_z
γ_x
γ_y
α_y
d
α_x
109
VEHICLE ORIENTATION SENSOR
α_x
α_y
α_z
$\arctan\left(\frac{\alpha_x}{\alpha_z}\right)$
ANGLE CALCULATOR
θ_A
150
135
$\vec{g}$
140
160
POSITION CALCULATOR
$\theta_C = \theta_B - \theta_A$
$d = (\rho - \theta_A) \times K$
725
LINEAR RAIL ACTUATOR
SEAT-MOTION CONTROLLER
CURRENT θ_C, CURRENT d
185
SEAT-BACK ACTUATOR
180
MOVER CONTROLLER
175
MEMORY RECALL
165
MEMORY
θ_C(Pref)
d (Pref)
OCCUPANT INPUT
170

FIG. 7

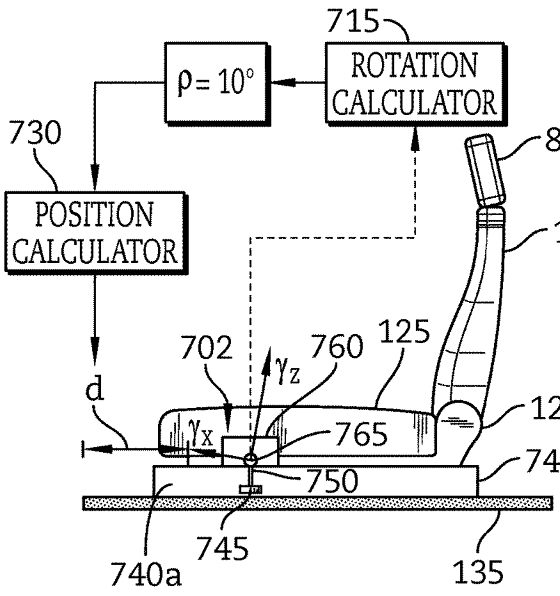


FIG. 8A

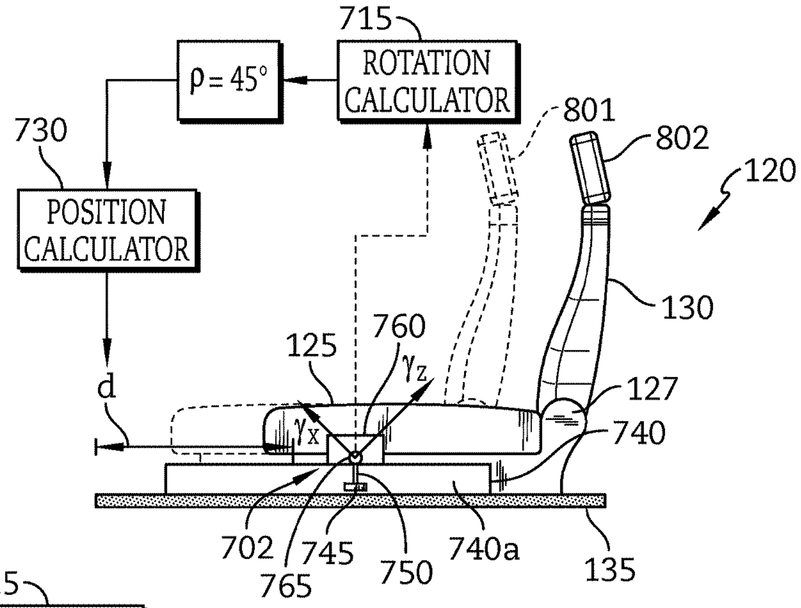


FIG. 8B

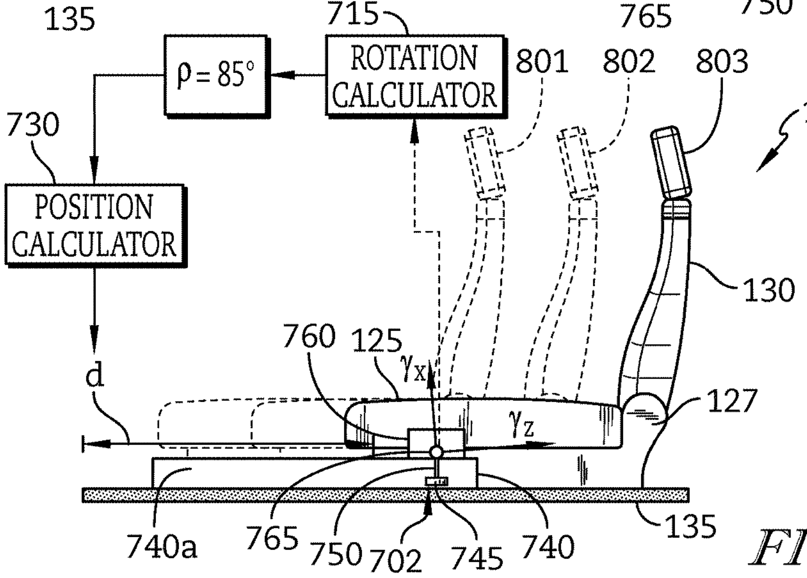


FIG. 8C

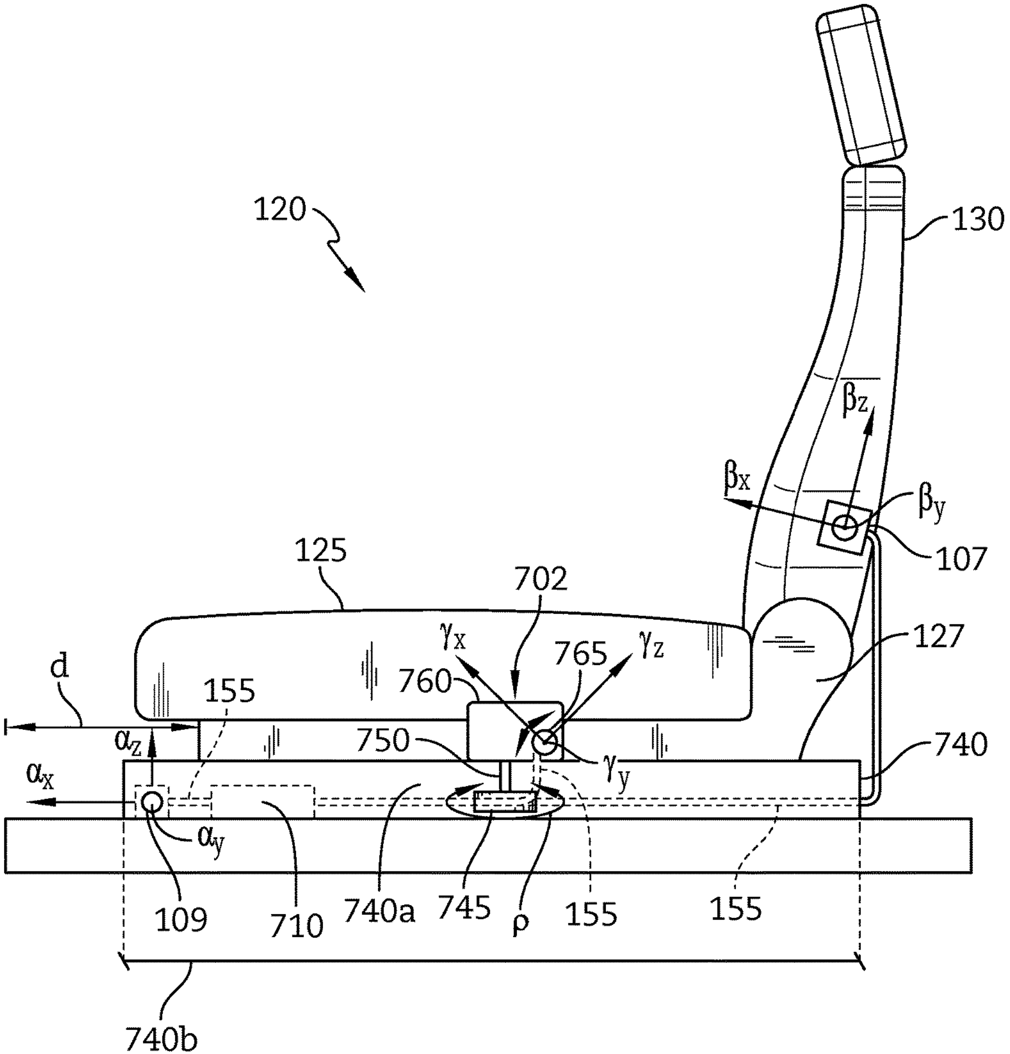

120
130
β_z
β_x
β_y
107
125
702
γ_x
765
γ_z
127
d
760
155
α_z
750
γ_y
740
α_x
α_y
109
710
740a
745
ρ
155
155
740b

FIG. 9

SEAT POSITION SENSING AND ADJUSTMENT

PRIORITY CLAIM

This application claims priority under 35 U.S.C. §119(e) to U.S. Provisional Application Ser. No. 62/063,679, filed Oct. 14, 2014, which is expressly incorporated by reference herein.

BACKGROUND

The present disclosure relates to a seat position sensing system, and in particular to a seat position sensing system within a passenger vehicle. More particularly, the present disclosure relates to a seat position sensing system with sensors.

SUMMARY

According to the present disclosure, a vehicle seat includes a seat foundation coupled to a floor of a vehicle, a seat bottom coupled to the seat foundation to move back and forth along a longitudinal axis relative to the floor, and a seat back coupled to the seat bottom to extend upwardly away from the seat bottom. The seat back pivots about an axis relative to the seat bottom.

In illustrative embodiments, the vehicle seat further includes a seat-position sensing system that includes a seat-orientation unit and a seat-motion controller. The seat-orientation unit includes a vehicle-orientation sensor in the form of an accelerometer coupled to the vehicle floor and configured to sense a gravity-based incline angle of the vehicle floor, and also includes a seat-back sensor in the form of an accelerometer coupled to the seat back to move therewith and configured to sense a gravity-based recline angle of the seat back.

In illustrative embodiments, the seat-orientation unit also includes a linear position sensor having an accelerometer whose readings can be used to compute a longitudinal position of the vehicle seat relative to the vehicle floor. The accelerometer is rotatably coupled through a reduction unit to a roller that rolls along a track affixed to the vehicle floor as the vehicle seat moves longitudinally forwards and backwards. A distance of longitudinal movement of the vehicle seat can be computed based on an amount of rotation of the accelerometer.

Additional features of the present disclosure will become apparent to those skilled in the art upon consideration of illustrative embodiments exemplifying the best mode of carrying out the disclosure as presently perceived.

BRIEF DESCRIPTIONS OF THE DRAWINGS

The detailed description particularly refers to the accompanying figures in which:

FIG. **1** is a perspective and diagrammatic view of a seat position sensing system including a seat-orientation unit configured to sense an orientation of a vehicle floor and a seat back relative to gravity so that a recline angle for the seat back relative to the vehicle floor may be calculated, and a seat-motion controller configured to move or facilitate manual adjustment of the seat back to predetermined angles of recline stored in the seat-motion controller;

FIG. **2** is an elevation view of the seat position sensing system of FIG. **1** showing that the seat-orientation unit includes a vehicle-orientation sensor coupled to the vehicle floor and configured to sense a gravity-based incline angle of the vehicle relative to gravity and a seat-back sensor coupled to the seat back to move therewith and configured to sense a gravity-based recline angle of the seat back relative to gravity and suggesting that the seat-orientation unit determines an adjusted recline angle of the seat back relative to the vehicle floor by subtracting the gravity-based incline angle of the vehicle floor from the gravity-based recline angle of the seat back;

FIGS. **3**A and **3**B are a series of elevation views of the seat position sensing system of FIG. **1** suggesting that the gravity-based incline angle measured by the vehicle-orientation sensor varies depending on the angle of incline of the vehicle floor relative to gravity;

FIG. **4** is a perspective view of the seat position sensing system of FIG. **1** with portions broken away to reveal the vehicle-orientation sensor coupled to the vehicle floor, the seat-motion controller coupled to the vehicle floor and to the vehicle-orientation sensor, and the seat-back sensor coupled to the seat back and to the seat-motion controller;

FIG. **5** is a perspective view of a vehicle including a seat position sensing system in accordance with the present disclosure showing that the vehicle is located on a hill causing the vehicle to have a gravity-based incline angle (θ_A) and a gravity-based tilt angle (θ_D);

FIG. **6** is a perspective view of the seat position sensing system of FIG. **5** suggesting that the gravity-based incline angle of the vehicle is not influenced by the presence of the gravity-based tilt angle of the vehicle;

FIG. **7** is a perspective and diagrammatic view of a second embodiment of a seat position sensing system in accordance with the present disclosure showing that the seat-orientation unit further includes a linear position sensor coupled to the seat bottom to move therewith and configured to provide measurements used to calculate a longitudinal position of the vehicle seat relative to the vehicle floor;

FIGS. **8**A-C are a series of elevation views of the seat position sensing system of FIG. **7** showing a vehicle seat at three respective longitudinal positions relative to the vehicle floor, and showing that vector measurements relative to gravity from the linear position sensor are used to calculate a rotation of the linear position sensor and that the computed rotation is used to calculate the longitudinal position of the vehicle seat; and

FIG. **9** is an elevation view of the seat position sensing system of FIG. **7** showing that the linear position sensor includes an accelerometer, a roller configured to roll along a track affixed to the vehicle floor as the vehicle seat moves longitudinally forwards or backwards, and a gearbox that interconnects the accelerometer and the roller to cause rotation of the roller to be translated into rotation of the accelerometer so that the longitudinal position of the vehicle seat may be calculated.

DETAILED DESCRIPTION

A first embodiment of a seat position sensing system **100** in accordance with the present disclosure is shown, for example, in FIGS. **1-6**. A second embodiment of a seat position sensing system **700** is shown, for example, in FIGS. **7-9**. Seat position sensing system **100** calculates a recline angle for a seat back relative to a vehicle floor, and in illustrative embodiments moves or facilitates manual adjustment the seat back to a previously calculated, occupant-preferred recline angle in response to occupant instructions. Seat position sensing system **700** also calculates a recline angle for a seat back relative to a vehicle floor, and in addition calculates a longitudinal position of the vehicle seat relative to the vehicle floor. In illustrative embodiments, seat position sensing system **700** moves or facilitates manual adjustment of the seat back to a previously calculated, occupant-preferred recline angle and moves or facilitates manual adjustment of the seat to a previously calculated, occupant-preferred longitudinal position in response to occupant instructions.

A seat position sensing system **100** (also called occupant-support sensing system **100**) in accordance with the present disclosure is shown in FIGS. **1-6**. Seat position sensing system **100** is used, for example, in a vehicle **143** in connection with a vehicle seat **120** (also called an occupant support **120**) having a seat bottom **125** and a seat back **130**. Seat bottom **125** includes a seat foundation **127** anchored to a vehicle floor **135**. Seat back **130** extends upwardly from seat bottom **125** and is rotationally movable in relation to seat bottom **125** about pivot axis **195** through either powered or manual mechanisms, as will be described below. Variable angles of orientation exist among seat back **130**, seat bottom **125**, vehicle floor **135**, and a reference plane **140**. Reference plane **140** provides a measurement reference for variable angles of orientation to be discussed herein, and is established such that a gravity vector (g) extends normal to reference plane **140** as shown in FIGS. **1-6**.

Seat position sensing system **100** includes a seat-orientation unit **105** (also called support-orientation unit **105**) and a seat-motion controller **110** (also called support-motion controller **110**). Seat-orientation unit **105** senses orientations of seat back **130** and vehicle floor **135** relative to gravity and communicates these orientations to seat-motion controller **110**. Seat-motion controller **110** calculates a vehicle incline angle, an actual seat back recline angle, and an adjusted seat back recline angle relative to the vehicle incline angle. By calculating an adjusted seat back recline angle relative to the vehicle incline angle, seat position sensing system **100** can sense and store a recline angle of seat back **130** in a manner that controls for uneven terrain on which vehicle **143** may drive, such as inclined hills. This allows seat position sensing system **100** to store occupant-preferred recline angles for seat back **130**, and to later move or facilitate manual adjustment of seat back **130** to occupant-preferred recline angles, regardless of the terrain on which vehicle **143** is positioned.

Seat-orientation unit **105** includes a vehicle orientation sensor **109** and a seat-back sensor **107**. Vehicle orientation sensor **109** is configured to sense an orientation of vehicle **143**, and in particular vehicle floor **135**, relative to gravity. Seat-back sensor **107** is configured to sense an orientation of seat back **130**, and in particular a recline angle of seat back **130**, relative to gravity.

To sense an orientation of vehicle floor **135** relative to gravity, vehicle orientation sensor **109** includes an accelerometer measuring and outputting accelerations (α_x), (α_y), and (α_z) relative to gravity along three directional axes x, y, and z, as suggested in FIGS. **1**, **2**, and **3**. Vehicle orientation sensor **109** communicates accelerations (α_x), (α_y), and (α_z) to seat-motion controller **110**, which calculates a vehicle incline angle (θ_A). Vehicle incline angle (θ_A) represents a variable angle between reference plane **140** and vehicle floor **135**. Thus, (θ_A) may take on smaller values when vehicle **143** is on flat terrain and may take on larger values when vehicle **143** is driving up a hill having a high grade. Accelerations (α_x), (α_y), and (α_z) may be encoded digitally and transmitted with any suitable resolution, and illustratively may be transmitted with 10 bit resolution. Vehicle orientation sensor **109** may discard a certain number of least significant bits, such as the two least significant bits, to suppress noise.

To sense a recline angle of seat back **130** relative to gravity, seat-back sensor **107** includes an accelerometer measuring and outputting accelerations (β_x), (β_y), and (β_z) relative to gravity along three directional axes x, y, and z, as suggested in FIGS. **1** and **2**. Seat-back sensor **107** communicates accelerations (β_x), (β_y), and (β_z) to seat-motion controller **110**, which calculates an actual seat back recline angle (θ_B). Actual seat back recline angle (θ_B) represents a variable angle between seat back **130** and reference plane **140**. Thus, (θ_B) may take on larger values in situations where seat back **130** is reclined backward, and may also take on larger values when vehicle **143** is positioned on a hill having a high grade. Accelerations (β_x), (β_y), and (β_z) may be encoded digitally and transmitted with any suitable resolution, and illustratively may be transmitted with 10 bit resolution. Seat-back sensor **107** may discard a certain number of least significant bits, such as the two least significant bits, to suppress noise.

Seat-motion controller **110** then subtracts vehicle incline angle (θ_A) from actual seat back recline angle (θ_B) to calculate an adjusted seat back recline angle (θ_C). Adjusted seat back recline angle (θ_C) represents a variable angle between seat back **130** and vehicle floor **135**, as suggested in FIGS. **1** and **2**. As a result, adjusted seat back recline angle (θ_C) measures the seat back recline angle, controlling for any uneven terrain that vehicle **143** may be driving on, such as an inclined hill. Adjusted seat back recline angle (θ_C) will take on larger values in situations where seat back **130** reclines backward, but will generally not change when vehicle **143** moves from flat terrain to inclined terrain and vice versa.

By calculating adjusted seat back recline angle (θ_C), seat positioning system **100** can gauge an amount of seat back recline in a manner that is independent of terrain on which vehicle **143** is driving. This is beneficial because the terrain may vary from one moment to the next, causing variations in the angular orientation of vehicle **143**. A vehicle occupant, however, will generally seek a comfortable seat orientation relative to vehicle **143** regardless of angular orientations of vehicle **143**. As such, from an occupant comfort perspective, adjusted seat back recline angle (θ_C) is more relevant than actual seat back recline angle (θ_B).

Seat-motion controller includes a first angle calculator **150** for calculating vehicle incline angle (θ_A), a second angle calculator **151** for calculating actual seat back recline angle (θ_B), and a position calculator **160** for computing adjusted seat back recline angle (θ_C). To calculate vehicle incline angle (θ_A), first angle calculator **150** uses mathematical formulae that factor how vehicle incline angle (θ_A) varies as a function of accelerations (α_x), (α_y), and (α_z), each of which are measured relative to gravity, as suggested by FIG. **2**. In this illustrative embodiment, the formula $[\arctan((\alpha_x)/(\alpha_z))]$ is used to compute (θ_A), as shown in FIG. **1**. Similarly, second angle calculator **151** uses mathematical formulae that factor how actual seat back recline angle (θ_B) varies as a function of accelerations (β_x), (β_y), and (β_z), each of which are measured relative to gravity, as suggested in FIG. **2**. In this illustrative embodiment, the formula $[90°+\arctan((\beta_x)/(\beta_z))]$ is used to compute (θ_B).

Position calculator **160** computes adjusted seat back recline angle (θ_C) as a difference between actual seat back recline angle (θ_B) and vehicle incline angle (θ_A)—i.e., $[(\theta_B)-(\theta_A)]$. This is because, as explained, adjusted seat back recline angle (θ_C) represents a recline angle of the seat back

130 relative to an incline angle of the vehicle **143**, which enables the seat position sensing system **100** to control for inclines on which the vehicle **143** may be driving.

The operation of the first angle calculator **150** is illustrated in more detail by FIGS. **3**A and **3**B. FIG. **3**A shows a situation in which vehicle **143** is on a moderate incline, such that vehicle incline angle (θ_A) is 20 degrees. Here, acceleration (α_y) may be close to 0 because its directional orientation is approximately perpendicular to gravity vector (g). Acceleration (α_z) may have large magnitude, because its directional orientation is only 20 degrees removed from diametrically opposing gravity vector (g). Acceleration (α_x) may have a relatively small magnitude, because its directional orientation is only 20 degrees removed from being perpendicular to gravity vector (g). A relatively large value for (α_z) in combination with a relatively small value for (α_x) results in a relatively small quotient $[(\alpha_x)/(\alpha_z)]$, which in turn results in a relatively small result for the $[\arctan((\alpha_x)/(\alpha_z))]$ calculation, namely, 20°.

FIG. **3**B, in contrast, shows a situation in which vehicle **143** is on a steeper incline, with vehicle incline angle (θ_A) being 45 degrees. Here, acceleration (α_y) may still be close to 0 because its directional orientation is approximately perpendicular to gravity vector (g). Acceleration (α_z) may be smaller in magnitude in comparison to FIG. **3**B, because its directional orientation is farther removed from diametrically opposing, and closer to being perpendicular to, gravity vector (g). Acceleration (α_x), on the other hand, may have increased in magnitude in comparison to FIG. **3**B, because its directional orientation is farther removed from being perpendicular to gravity vector (g). In this example, accelerations (α_z) and (α_x) are equal in magnitude, resulting in a higher value for the quotient $[(\alpha_x)/(\alpha_z)]$ as compared to the example of FIG. **3**A. This results in a larger value for the $[\arctan((\alpha_x)/(\alpha_z))]$ calculation than the example of FIG. **3**A, namely, 45°.

The operation of second angle calculator **151** is similar, in this example, to the operation of first angle calculator **150**, with two differences. First, accelerations (β_x), (β_y), and (β_z) measured by seat-back sensor **107** are used rather than accelerations (α_x), (α_y), and (α_z). Second, second angle calculator **151** adds 90° to the $[\arctan((\beta_x)/(\beta_z))]$ computation. This is because seat back **130** is in a vertically upright position when seat back **130** is not reclined at all. As such, a 0° seat back recline angle (θ_B) should correspond to a situation in which seat back **130** is actually 90° displaced from reference plane **140**. As such, a 90° adjustment is added to the computation $[\arctan((\beta_x)/(\beta_z))]$.

As explained, position calculator **160** computes adjusted seat back recline angle (θ_C) as a difference between actual seat back recline angle (θ_B) and vehicle incline angle (θ_A)—i.e., $[(\theta_B)-(\theta_A)]$. After an occupant of vehicle **143** adjusts seat back **130** to a desired orientation, position calculator **160** may store the value of adjusted seat back recline angle (θ_C), as computed at that time, to memory **165**. Memory **165** stores this value as a preferred seat back recline angle (θ_C(pref)). Memory **165** may include any suitable form of transitory or non-transitory computer-readable media, including memory media such as RAM, ROM, EEPROM, CD-ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other medium which can be used to carry or store computer-readable data.

By storing (θ_C(pref)) in memory, an occupant may later instruct seat motion controller **110** to return seat back **130** to preferred seat back recline angle (θ_C(pref)). In other embodiments, an occupant may later manually move seat back **130**, and seat motion controller **110** may engage a locking mechanism when seat back **130** is at the preferred seat back recline angle (θ_C(pref)). Thus, in illustrative embodiments, seat-motion controller **110** also includes components that subsequently adjust seat back **130** to a preferred orientation, or that disengage and engage locking mechanisms at appropriate times based on manual occupant adjustments. These components include a mechanism for occupant input **170**, a memory recall **175**, a mover controller **180**, and a seat-back actuator **185**.

As explained, an occupant, during a subsequent use of vehicle **143**, may desire to have seat back **130** adjusted to preferred seat back recline angle (θ_C(pref)). Seat motion controller **110** may include powered mechanisms for adjusting seat back **130**. Illustratively, the occupant uses occupant input **170** to instruct seat position sensing system **100** that seat back **130** should be adjusted to preferred seat back recline angle (θ_C(pref)). Occupant input can be provided by a variety of mechanisms. For example, vehicle **143** may include an electrical push-button (not shown) programmed to initiate movement of seat back **130** to a preferred orientation. Alternatively, vehicle **143** may include a touch screen interface (not shown) provided on or near a dashboard, within a head unit, or otherwise visible to the occupant. By navigating among graphical icons displayed on the touch screen interface, the occupant may select a graphical icon that initiates movement of seat back **130** to a preferred orientation. In response to receiving an instruction from the occupant through occupant input **170**, memory recall **175** retrieves preferred seat back recline angle (θ_C(pref)). Memory recall **175** communicates (θ_C(pref)) to mover controller **180**.

Illustratively, mover controller **180** automatically rotates seat back **130** relative to seat bottom **125** as necessary until a current seat back recline angle (θ_C), as computed by position calculator **160**, is equal to preferred seat back recline angle (θ_C(pref)). Mover controller receives from position calculator **160** a current seat back recline angle (θ_C). Mover controller **180** sends instructions to seat-back actuator **185** to rotate seat back **130** relative to seat bottom **125** either forwards or backwards, depending on how current seat back recline angle (θ_C) compares to (θ_C(pref)). Seat-back actuator **185** may power a motor (not shown) that can rotate seat back **130** relative to seat bottom **125** about pivot axis **195**.

For example, if current seat back recline angle (θ_C) is larger than (θ_C(pref)), mover controller **180** will instruct seat-back actuator **185** to rotate seat back **130** forward. If current seat back recline angle (θ_C) is smaller than (θ_C(pref)), mover controller **180** will instruct seat-back actuator **185** to rotate seat back **130** backward. Seat-back actuator **185** will power a motor, which will perform appropriate rotations of seat back **130**.

As seat back actuator **185** rotates seat back **130** through the powered motor, mover controller **180** continues to receive results of updated calculations from position calculator **160** regarding current seat back recline angle (θ_C). For example, mover controller **180** retrieves updated calculations at a predetermined sampling rate, such as 10 times per second, 100 times per second, etc. Mover controller **180** continues to issue instructions to seat back actuator **185** as appropriate, depending on how current seat back recline angle (θ_C) compares to (θ_C(pref)). For example, if seat back actuator **185** rotates seat back **130** too far, as to overshoot (θ_C(pref)), mover controller **180** may instruct seat back actuator **185** to reverse direction of rotation of seat back **130**.

When current seat back recline angle (θ_C) is equal to, or within a predetermined tolerance of, (θ_C(pref)), mover controller **180** instructs seat back actuator **185** to cease rotation. Seat back **130** will then be in the orientation preferred by the occupant.

In other embodiments, mover controller **180** facilitates an occupant in manually rotating seat back **130** relative to seat bottom **125** as necessary until current seat back recline angle (θ_C) is equal to preferred seat back recline angle (θ_C(pref)). In such embodiments, vehicle seat **120** may include a selectively releasable locking mechanism (not shown) powered by seat-back actuator **185** that can occupy open and locked positions. In an open position, seat back **130** is permitted to rotate relative to seat bottom **125**. In a locked position, seat back **130** is blocked from rotation relative to seat bottom **125**. Seat-back actuator **185** keeps the locking mechanism in an open position as the occupant adjusts seat back **130** towards a preferred orientation, and then issues instructions to the locking mechanism to engage in a locked position in response to seat back **130** attaining the preferred orientation.

Illustratively, prior to receiving instructions from an occupant through occupant input **170**, the locking mechanism may be in a locked position by default. In response to receiving instructions from an occupant through occupant input **170**, memory recall **175** communicates (θ_C(pref)) to mover controller **180**. Mover controller **180** obtains current seat back recline angle (θ_C) from position calculator **160**, which it compares with (θ_C(pref)). If current seat back recline angle (θ_C) is not equal to (θ_C(pref)), mover controller **180** issues a signal to seat-back actuator **185** indicating that (θ_C) is not equal to (θ_C(pref)). Seat-back actuator **185** powers the locking mechanism as to disengage and assume an open position.

The occupant can then rotate seat back **130** relative to seat bottom **125** using seat-back actuator **185**. Vehicle **143** may include a display that indicates to the occupant whether the occupant should rotate seat back **130** forwards or backwards in order to place seat back **130** in the preferred orientation. For example, if current seat back recline angle (θ_C) is larger than (θ_C(pref)), vehicle **143** may indicate that seat back **130** should be rotated forward. If current seat back recline angle (θ_C) is smaller than (θ_C(pref)), vehicle **143** may indicate that seat back **130** should be rotated backward.

To rotate seat back **130** forwards or backwards, vehicle **143** includes, for example, an electronic push-button, electronic dial, or other electronic mechanism (not shown) that allows the occupant to instruct seat-back actuator **185** to rotate seat back **130** forwards or backwards. Alternatively, seat-back actuator **185** may include manual controls, such as knobs or levers (not shown), through which the occupant can cause rotation of seat back **130** forwards or backwards.

As the occupant causes rotation of seat back **130**, mover controller **180** continues to receive updated calculations from position calculator **160** regarding current seat back recline angle (θ_C), and compares those values to (θ_C(pref)). For example, mover controller **180** may retrieve updated calculations at a predetermined sampling rate, such as 10 times per second, 100 times per second, etc.

In response to determining that current seat back recline angle (θ_C) is equal to, or within a predetermined tolerance of, (θ_C(pref)), mover controller **180** may instruct the seat-back actuator **185** to engage the locking mechanism. In response, the seat-back actuator **185** may power the locking mechanism to engage and assume a locked position. This prevents the occupant from further rotating seat back **130**, thus facilitating the occupant in placing and locking vehicle seat **120** in a preferred orientation.

Depending on the sampling at which mover controller **180** receives updated calculations from position calculator **160** and the responsive time with which seat-back actuator **185** can cause the locking mechanism to engage in response to instructions from mover controller **180**, the occupant may rotate seat back **130** too far, as to overshoot preferred seat back recline angle (θ_C(pref)). This is because current seat back recline angle (θ_C) may equal preferred seat back recline angle (θ_C(pref)) at a particular point in time, but mover controller **180** may not receive an updated calculation on current seat back recline angle (θ_C) until a later point in time dependent upon the sampling rate. Moreover, the locking mechanism may not engage until a still further point in time, depending on signaling speeds of mover controller **180** and seat-back actuator **185**, and the response time of the locking mechanism.

Thus, in certain embodiments, mover controller **180** may implement predictive algorithms that issue a signal to seat-back actuator **185** at a point in time prior to the occupant reclining seat back **130** to preferred seat back recline angle (θ_C(pref)). Mover controller **180** may be programmed with information regarding its sampling rate, a previously determined signaling speed for mover controller **180** and seat-back actuator **185**, and a previously determined response time for the locking mechanism. Using this information, mover controller **180** may compute an expected time delay between when it issues a signal to seat-back actuator **185** indicating that the locking mechanism should engage, and when the locking mechanism actually engages.

During use, mover controller **180** may determine a rotational speed with which the occupant is rotating seat back **130** about pivot axis **195**, and use extrapolation based on the rotational speed to determine a future point in time at which seat back **130** is predicted to achieve preferred seat back recline angle (θ_C(pref)). If the current time plus the expected time delay is equal to or within a predetermined tolerance of the future point in time at which seat back **130** is predicted to achieve preferred seat back recline angle (θ_C(pref)), mover controller **180** issues a signal to seat-back actuator **185**, which powers the locking mechanism as to assume a locked position. By the time the locking mechanism engages, seat back **130** should have achieved an angle of recline approximately equal to (θ_C(pref)).

As explained above, seat position sensing system **100** calculates an adjusted seat back recline angle (θ_C) that controls for a vehicle incline angle (θ_A), which may arise because vehicle **143** is driving uphill. In another respect, seat position sensing system **100** also controls for uneven terrain that may cause vehicle **143** to tilt about an x-axis, resulting in a vehicle tilt angle (θ_D), as suggested in FIGS. **5-6**. Vehicle **143** is on an uphill and tilted terrain **190** as shown in FIG. **5**. This causes vehicle floor **135** to form a positive vehicle incline angle (θ_A), and a positive vehicle tilt angle (θ_D) with respect to reference plane **140**.

FIG. **6** illustrates that first angle calculator **150**, using calculations described above in connection with FIG. **1**, controls for a positive vehicle tilt angle (θ_D). FIG. **6** compares the calculations performed by first angle calculator **150** in the situations in which vehicle tilt angle (θ_D) is 0° (i.e., there is no tilt) and situations in which vehicle tilt angle (θ_D) is positive. As shown in FIG. **6**, the calculation performed in both situations is the same, namely, [$\arctan((\alpha_x)/(\alpha_z))$].

Illustratively, the calculations relevant to the situation in which vehicle tilt angle (θ_D) is 0° is shown on the left-hand side of FIG. **6**. Here, acceleration (α_x), as measured by vehicle orientation sensor **109**, is equal to an acceleration of gravity scaled by the factor sin(θ_A). Thus, as vehicle incline angle (θ_A) increases from 0° to 90°, acceleration (α_x) will increase in value from 0 to the acceleration of gravity. Similarly, acceleration (α_z), as measured by vehicle orientation sensor **109**, is equal to an acceleration of gravity scaled by the factor cos(θ_A). Thus, as vehicle incline angle (θ_A) increases from 0° to 90°, acceleration (α_z) will decrease in value from the acceleration of gravity to 0. As previously explained, angle calculator **150** computes vehicle incline angle (θ_A) as [arctan((α_x)/(α_y))].

The calculations relevant to the situation in which vehicle tilt angle (θ_D) is greater than 0° is shown on the right-hand side of FIG. **6**. As shown, accelerations (α_x) and (α_z) will both further be scaled by a quantity cos(θ_D). Thus, as angle of vehicle tilt increases from 0° to 90°, acceleration (α_x) and (α_z) will both decrease. However, because both (α_x) and (α_z) are decreased by the same factor of cos(θ_D), this factor cancels and has no net effect on the computation performed by angle calculator **150**—namely, [arctan((α_x)/(α_z))] is equal to [arctan((α_x)*cos(θ_D)/(α_z)*cos(θ_D))]. As such, angle calculator **150** arrives at the correct value for vehicle incline angle (θ_A) regardless of whether vehicle **143** also experiences a vehicle tilt angle (θ_D). For similar reasons, second angle calculator **151** likewise arrives at the correct value for actual seat back recline angle (θ_B) regardless of whether vehicle **143** experiences a vehicle tilt angle (θ_D).

Vehicle orientation sensor **109**, seat-back sensor **107**, and seat-motion controller **110** can be mounted in a variety of locations. Vehicle orientation sensor **109** is mounted illustratively to vehicle floor **135** at a location below a front end **125***a* of seat bottom **125**, as shown in FIGS. **1**, **2**, and **3**. However, vehicle orientation sensor **109** may be mounted in other suitable locations within vehicle **143**, including any location such that vehicle orientation sensor **109** inclines or declines along with vehicle floor **135** as vehicle incline angle (θ_A) changes (e.g., when vehicle **143** drives uphill or downhill). Generally, any location fixed relative to vehicle floor **135** may be suitable.

For example, because seat bottom **125** is provided on seat foundation **127** anchored to vehicle floor **135**, seat bottom **125** may maintain a consistent angular orientation relative to vehicle floor **135** as vehicle incline angle (θ_A) changes. Accordingly, in illustrative embodiments, vehicle orientation sensor **109** may be mounted to seat bottom **125**. In such an embodiment, the adjusted seat back recline angle would be computed relative to seat bottom **125**, rather than vehicle floor **135**. An exemplary adjusted seat back recline angle that is computed relative to seat bottom **125** is depicted in FIG. **1** as (θ_C(seat bottom)). Computing the adjusted seat back recline angle relative to seat bottom **125** would still allow seat position sensing system **100** to control for uneven terrain on which vehicle **143** may drive, because as vehicle **143** inclines, seat bottom **125** will incline in consistent angular relationship with vehicle **143**. For purposes of this illustrative explanation, however, an adjusted seat back recline angle (θ_C) computed relative to vehicle floor **135** has be used, rather than (θ_C(seat bottom)), even though either would be suitable.

Seat-back sensor **107** is illustratively mounted to a crossbar **145** that spans laterally across a rear surface **130***a* of seat back **130**, as shown in FIG. **4**. However, seat-back sensor **107** may be mounted in other suitable locations, including any location such that seat-back sensor **107** maintains a consistent angular orientation relative to seat back **130** as seat back **130** rotates relative to seat bottom **125**. In illustrative embodiments, seat-back sensor **107** is mounted adjacent to a lower of rear surface **130***a*, closer to pivot axis **195** than to head rest **200**. During driving conditions, seat back **130** may rotate back and forth about pivot axis **195** in vibratory fashion due to rough terrain encountered by vehicle **143**. Seat-back sensor **107**, being affixed to seat back **130**, will also experience these vibratory motions, which may introduce unwanted noise components into the signals generated by seat-back sensor **107** communicating accelerations (α_x), (α_y), and (α_z) to seat-motion controller **110**. During such vibratory motions, higher regions of seat back **130**, such as those closer to head rest **200**, may experience larger displacements from such vibratory motion than lower regions of seat back **130**, such as those closer to pivot axis **195**. As such, mounting seat-back sensor **107** closer to pivot axis **195** may enable seat-back sensor **107** to generate signals less susceptible to noise caused by vibratory motions.

Seat-motion controller **110** is illustratively mounted to vehicle floor **135** below seat bottom **125** and rearward from vehicle orientation sensor **109**, as shown in FIGS. **2**-**4**. Seat-motion controller is in electrical communication with seat-back sensor **107** and vehicle orientation sensor **109** through electrical cabling **155**. However, seat-motion controller **110** may be located in any position within vehicle **143** such that it can be placed in wired or wireless electrical communication with seat-back sensor **107** and vehicle orientation sensor **109**.

Seat-motion controller **110**, including first angle calculator **150**, second angle calculator **151**, position calculator **160**, memory **165**, memory recall **175**, and mover controller **180**, may be implemented in software, compiled and stored to a memory as object code, and during operation of the seat position sensing system **100**, may be invoked for execution by a processor. In one implementation, the above-described components are implemented as a single system on a chip. The interconnections among the above-described components can be provided through any suitable electronic communication mechanism, such as a communication bus or cabling. In other implementations, the above-described components may be implemented on separate hardware modules and placed in communication with one another through any suitable electronic communication mechanism, such as a communication bus or cabling.

A second embodiment of a seat position sensing system **700** in accordance with the present disclosure is shown, for example, in FIGS. **7**-**9**. Seat position sensing system **700** enables the functionality of seat position sensing system **100**, and additionally calculates and stores a preferred longitudinal position of vehicle seat **120**. Thus, similar to seat position sensing system **100**, seat position sensing system **700** calculates an adjusted seat back recline angle (θ_C) for seat back **130** relative to vehicle floor **135**. Additionally, seat position sensing system **700** calculates a longitudinal position (d) of vehicle seat **120**, including seat bottom **125**, relative to vehicle floor **135**. In this illustrative embodiment, longitudinal position (d) is measured from a front end **127***a* of seat foundation **127** to a reference point on vehicle floor **135** towards the front of vehicle **143** (e.g., near a gas pedal, not shown). However, other reference points can be used to measure a longitudinal position of vehicle seat **120**, including any component in consistent movable relationship with vehicle seat **120** in combination with any component on or affixed to vehicle floor **135**.

Seat position sensing system **700** includes a seat-orientation unit **705** and a seat-motion controller **710**. Similar to seat-orientation unit **105**, discussed above, seat-orientation unit **705** senses an orientation of seat back **130** and an orientation of vehicle floor **135**. Seat-orientation unit **705** additionally generates outputs from a linear position sensor **702**, which are used to compute longitudinal position (d) of vehicle seat bottom **125**. Similar to seat-motion controller **110**, discussed above, seat-motion controller **710** calculates a vehicle incline angle, an actual seat back recline angle, and an adjusted seat back recline angle relative to the vehicle incline angle. Seat-motion controller **710** additionally calculates a rotation amount (ρ) of linear position sensor **702**, and uses rotation amount (ρ) to calculate a longitudinal position (d) seat bottom **125** relative to vehicle floor **135**.

Seat-orientation unit **705** includes several components that correspond to like components described in connection with seat position sensing system **100**. Illustratively, seat-orientation unit **705** includes vehicle orientation sensor **109** to sense an orientation of vehicle floor **135** relative to gravity by measuring and outputting accelerations (α_x), (α_y), and (α_z). Seat-orientation unit **705** also includes seat-back sensor **107** configured to sense an orientation of seat back **130** relative to gravity by measuring and outputting accelerations (β_x), (β_y), and (β_z).

Likewise, seat-motion controller **710** includes several components that correspond with components described in connection with seat position sensing system **100**. Thus, seat-motion controller **710** includes first angle calculator **150** for calculating vehicle incline angle (θ_A), second angle calculator **151** for calculating actual seat back recline angle (θ_B), and position calculator **160** for computing adjusted seat back recline angle (θ_C). Seat-motion controller **710** also includes memory **165** for storing preferred seat back recline angle (θ_C(pref)), occupant input **170** for receiving occupant inputs, memory recall **175** for retrieving preferred seat back recline angle (θ_C(pref)), and mover controller **180** and seat-back actuator **185** for either powered rotation or to facilitate manual adjustment of seat back **130**.

Seat-orientation unit **705** additionally includes linear position sensor **702**. Outputs from linear position sensor **702** are used by seat-motion controller **710** to compute longitudinal position (d) of seat bottom **125**. To generate outputs from which longitudinal position (d) can be calculated, linear position sensor **702** includes an accelerometer **765** that rotates as seat bottom **125** is moved, as suggested in FIGS. **8**A-**9**. Accelerometer **765** generates outputs that vary based on rotation amount (ρ) of accelerometer **765**. Based on the outputs of accelerometer **765**, seat-motion controller **710** computes rotation amount (ρ), as shown in FIG. **7**. Position calculator **160** then converts rotation amount (ρ) to longitudinal position (d) based on mathematical formulae, as shown in FIGS. **7**-**8**C.

Illustratively, linear position sensor **702** includes a roller **745** rotatably engaged with a track **740**, a rotating shaft **750**, a reduction unit **760**, and accelerometer **765**, as shown in FIGS. **8**A-**9**. Track **740** is fixedly mounted to vehicle floor **135**, and seat foundation **127** is slidably engaged with track **740**, such as through slide rails (not shown) that slidably couple with grooves in track **740**. Sliding seat foundation **127** enables seat bottom **125**, which is mounted to seat foundation **127**, to move forwards or backwards to desired longitudinal positions, carrying the entire vehicle seat **120** therewith. In certain embodiments, seat foundation **127** may move through powered mechanisms, and in other embodiments, seat foundation **127** may be moved manually by an occupant.

Linear position sensor **702** is coupled to seat bottom **125**, and moves longitudinally therewith. As seat bottom **125** moves, roller **745** rotatably engages with an outer surface **740***a* of track **740**. As such, the amount of rotation of roller **745** correlates with the amount of longitudinal displacement of seat bottom **125**. The rotation of roller **745** is transmitted through rotating shaft **750**, which is coupled to roller **745** as to rotate therewith. Rotating shaft **750** transmits rotation through reduction unit **760** to accelerometer **765**. In one example, reduction unit **760** is a gearbox, however, reduction unit **760** may be any other suitable alternative. In the example where reduction unit **760** is a gearbox, the gearbox includes a plurality of inter-meshed gears (not shown) having gear ratios selected such that accelerometer **765** rotates at a predefined rate of rotation relative to the longitudinal displacement of seat bottom **125**.

In illustrative embodiments, the predefined rate of rotation for accelerometer **765** is approximately 1.93° per 5 mm of longitudinal displacement of seat bottom **125**, or 2.58 mm per degree. Illustratively, the full longitudinal length **740***b* of track **740** is approximately 225 mm, providing for a total of approximately 87° of rotation of accelerometer **765** over the full longitudinal length **740***b* of track **740**. Other rates of rotation may be used, and larger amounts of rotation relative to longitudinal displacement of seat bottom **125** may increase accuracy. In illustrative embodiments, accelerometer **765** may have a rate of rotation sufficiently large such that accelerometer **765** may complete several full rotations as seat bottom **125** moves longitudinally along the full length **740***b* of track **740**—e.g., more than 360°. Because cable **155** connects to accelerometer **765**, as shown in FIG. **9**, and may rotate therewith, a cable spooler or other cable management mechanism may be provided such that cable **155** does not interfere with other componentry during rotations of accelerometer **765**.

As accelerometer **765** rotates according to its predefined rate of rotation, accelerometer **765** measures and outputs accelerations (γ_x), (γ_y), and (γ_z) relative to gravity along three directional axes x, y, and z, as suggested in FIGS. **7**-**9**. Linear position sensor **702** communicates accelerations (γ_x), (γ_y), and (γ_z) to rotation calculator **715**, which calculates a rotation amount (ρ) of accelerometer **765** using mathematical formulae. The mathematical formulae factor how rotation amount (ρ) varies as a function of accelerations (γ_x), (γ_y), and (γ_z), each of which are measured relative to gravity. In this illustrative embodiment, the formula $[\arctan((\gamma_x)/(\gamma_z))]$ is used to compute (ρ), as shown in FIG. **7**. Accelerations (γ_x), (γ_y), and (γ_z) may be encoded digitally and transmitted with any suitable resolution, and illustratively may be transmitted with 10 bit resolution. Linear position sensor **702** may discard a certain number of least significant bits, such as the two least significant bits, to suppress noise.

Rotation calculator **715** communicates rotation amount (ρ) to position calculator **160**, which converts rotation amount (ρ) to longitudinal position (d) of seat bottom **125**. Position calculator **160** determines longitudinal position (d) by controlling for any uneven terrain that vehicle **143** may be driving on, and by factoring the predefined rate of rotation of accelerometer **765**.

Position calculator **160** controls for uneven terrain that vehicle **143** may be driving on by subtracting vehicle incline angle (θ_A) from (ρ)—i.e., $[(\rho)-(\theta_A)]$. As previously explained, uneven terrain, such as hills, may cause vehicle **143** to be positioned at a vehicle incline angle (θ_A). This may cause accelerometer **765** to incline therewith, causing changes to output accelerations (γ_x), (γ_y), and (γ_z) and thereby causing changes to computed rotation amount (ρ). Because vehicle incline angle (θ_A) may vary from one moment to the next, rotation amount (ρ) should be controlled for vehicle incline angle (θ_A), so that longitudinal position calculations for seat bottom **125** are not improperly skewed by changing angles of vehicle incline angle (θ_A).

After controlling for vehicle incline angle (θ_A), position calculator **160** factors the predefined rate of rotation of accelerometer **765** by scaling with a constant scaling factor. For example, where accelerometer **765** rotates at a rate of 1.93° per 5 mm of longitudinal displacement, position calculator **160** illustratively scales $[(\rho)-(\theta_A)]$ by 2.58 mm/degree. The resulting value represents longitudinal position (d) of seat bottom **125** relative to vehicle floor **135**.

FIGS. **8**A-**8**C illustrate the operation of linear position sensor **702**, rotation calculator **715**, and position calculator **160**. In FIG. **8**A, vehicle seat **120** occupies a first position **801**. Accelerometer **765** of linear position sensor **702** occupies a first orientation, as reflected by the orientation of the x and z directional axes of accelerometer **765**. At this orientation, rotation calculator computes (ρ) to be 10°. Position calculator computes the corresponding longitudinal position (d) to be a relatively small amount. In FIG. **8**B, an occupant has moved vehicle seat **120** to a second position **802** rearward of first position **801**. As vehicle seat **120** moves to second position **802**, roller **745** rotates along outer surface **740***a* of track **740**, causing rotation of accelerometer **765** to a second orientation, as reflected by the new orientation of its x and z directional axes. At this orientation, rotation calculator computes (ρ) to be 45°. Position calculator computes the corresponding longitudinal position (d) to be a second, intermediate amount. Finally, in FIG. **8**C, an occupant has moved vehicle seat **120** to a third position **803** rearward of second position **802**. As vehicle seat **120** moves to third position **803**, roller **745** rotates still further, causing rotation of accelerometer **765** to a third orientation, as reflected by the new orientation of its x and z directional axes. At this orientation, rotation calculator computes (ρ) to be 85°. Position calculator computes the corresponding longitudinal position (d) to be a third, relatively large amount.

After an occupant of vehicle **143** adjusts seat bottom **125** to a desired longitudinal position, position calculator **160** may store longitudinal position (d) of seat bottom **125**, as computed at that time, to memory **165**. Memory **165** stores this value as a preferred longitudinal position (d(pref)) of seat bottom **125**. By storing (d(pref)) in memory, an occupant may later instruct seat motion controller **710** to return seat bottom **125** to preferred longitudinal position (d(pref)). Alternatively, the occupant may manually adjust seat bottom **125**, with seat motion controller **710** controlling a locking mechanism that locks seat bottom **125** once it arrives at preferred longitudinal position (d(pref)). Thus, in illustrative embodiments, seat-motion controller **710** includes components that subsequently adjust, or facilitate a user in manually adjusting, seat bottom **125** to preferred longitudinal position (d(pref)). These components include occupant input **170**, memory recall **175**, mover controller **180**, and linear rail actuator **725**.

An occupant, during a subsequent use of vehicle **143**, may desire to have seat bottom **125** adjusted to preferred longitudinal position (d(pref)). This is may be achieved through powered mechanisms similar to the manner by which seat back **130** may be adjusted to preferred seat back recline angle (θ_C(pref)) through powered mechanisms. Illustratively, the occupant uses occupant input **170** to instruct seat position sensing system **700** that seat bottom **125** should be adjusted to preferred longitudinal position (d(pref)). In response to receiving an instruction from the occupant through occupant input **170**, memory recall **175** retrieves preferred longitudinal position (d(pref)) from memory **165** and communicates (d(pref)) to mover controller **180**.

In certain embodiments, mover controller **180** automatically adjusts seat bottom **125** as necessary until a current longitudinal position (d), as computed by position calculator **160**, is equal to preferred longitudinal position (d(pref)). In other embodiments, mover controller **180** facilitates an occupant in manually sliding seat bottom **125** relative to vehicle floor **135** as necessary until current longitudinal position (d) is equal to preferred longitudinal position (d(pref)).

In embodiments in which mover controller **180** automatically adjusts seat bottom **125**, mover controller receives from position calculator **160** a current longitudinal position (d). Mover controller **180** sends instructions to linear rail actuator **725** to slide seat foundation **127** along track **740** via slide rails (not shown) either forwards or backwards, depending on how current longitudinal position (d) compares to (d(pref)). For example, if current longitudinal position (d) is larger than (d(pref)), mover controller **180** will instruct linear rail actuator **725** to slide seat foundation **127** forward. If current longitudinal position (d) is smaller than (d(pref)), mover controller **180** will instruct linear rail actuator **725** to slide seat foundation **127** backward.

As linear rail actuator **725** slides seat foundation **127**, mover controller **180** continues to receive results of updated calculations from position calculator **160** regarding current longitudinal position (d). For example, mover controller **180** retrieves updated calculations at a predetermined sampling rate, such as 10 times per second, 100 times per second, etc. Mover controller **180** continues to issue instructions to linear rail actuator **725** as appropriate, depending on how current longitudinal position (d) compares to (d(pref)). For example, if linear rail actuator **725** slides seat foundation **127** too far, as to overshoot (d(pref)), mover controller **180** may instruct linear rail actuator **725** to reverse the direction of sliding.

When current longitudinal position (d) is equal to, or within a predetermined tolerance of, (d(pref)), mover controller **180** instructs linear rail actuator **725** to cease movement. Seat bottom **125** will then be in the longitudinal position preferred by the occupant.

In other embodiments, mover controller **180** facilitates an occupant in manually adjusting seat bottom **125** relative to vehicle floor **135**. In such embodiments, vehicle seat **120** may include a selectively releasable locking mechanism (not shown) powered by linear rail actuator **725**. Upon signaling from linear rail actuator **725**, the locking mechanism can disengage to assume an open position, or engage to assume a locked position. In an open position, seat foundation **127** is permitted to slide relative to vehicle floor **135**, allowing the occupant to manually adjust seat bottom **125**. In a locked position, seat foundation **127** is blocked from movement relative to vehicle floor **135**. Mover controller **180** keeps the locking mechanism in an open position as the occupant adjusts seat bottom **125** towards a preferred longitudinal position, and then locks the locking mechanism in response to seat bottom **125** attaining the preferred orientation.

Illustratively, prior to receiving instructions from an occupant through occupant input **170**, the locking mechanism may be in a locked position by default. In response to receiving instructions from an occupant through occupant input **170**, memory recall **175** retrieves and communicates (d(pref)) to mover controller **180**. Mover controller **180** obtains current longitudinal position (d) from position calculator **160**, which it compares with (d(pref)). If current longitudinal position (d) is not equal to (d(pref)), mover controller **180** issues a signal to linear rail actuator **725**, which releases the locking mechanism into an open position.

The occupant can then move seat bottom **125** by sliding seat foundation **127** relative to vehicle floor **135** using linear rail actuator **725**. Vehicle **143** may include a display that indicates to the occupant whether the occupant should slide seat bottom **125** forwards or backwards in order to place seat foundation **127** in the preferred position. For example, if current longitudinal position (d) is larger than (d(pref)), vehicle **143** may indicate that seat bottom **125** should be moved forward. If current longitudinal position (d) is smaller than (d(pref)), vehicle **143** may indicate that seat bottom **125** should be moved backward.

To slide seat foundation **127** forwards or backwards, vehicle **143** includes, for example, an electronic push-button, electronic dial, or other electronic mechanism (not shown) that allows the occupant to manually slide seat foundation **127** forwards or backwards. Alternatively, linear rail actuator **725** may include hand controls, such as knobs or levers (not shown), through which the occupant can manually cause movement of seat foundation **127** forwards or backwards.

As the occupant causes movement of seat bottom **125**, mover controller **180** continues to receive updated calculations from position calculator **160** regarding current longitudinal position (d), and compares those values to (d(pref)). For example, mover controller **180** may retrieve updated calculations at a predetermined sampling rate such as 10 times per second, 100 times per second, etc. In response to determining that current longitudinal position (d) is equal to, or within a predetermined tolerance of, (d(pref)), mover controller **180** may instruct linear rail actuator **725** to engage the locking mechanism to assume a locked position. This prevents the occupant from further sliding seat foundation **127**, thus facilitating the occupant in placing and locking vehicle seat **120** in a preferred position.

Depending on the sampling at which mover controller **180** receives updated calculations from position calculator **160** and the responsive time with which linear rail actuator **725** can cause the locking mechanism to engage in response to instructions from mover controller **180**, the occupant may move seat bottom **125** too far, as to overshoot preferred longitudinal position (d(pref)). This is because current longitudinal position (d) may equal preferred longitudinal position (d(pref)) at a particular point in time, but mover controller **180** may not receive an updated calculation on current longitudinal position (d) until a later point in time dependent upon the sampling rate. Moreover, the locking mechanism may not engage until a still further point in time, depending on signaling speeds of mover controller **180** and linear rail actuator **725**, and the response time of the locking mechanism.

Thus, in certain embodiments, mover controller **180** may implement predictive algorithms that issue a signal to linear rail actuator **725** at a point in time prior to the occupant moving seat bottom **125** to preferred longitudinal position (d(pref)). Mover controller **180** may be programmed with information regarding its sampling rate, a previously determined signaling speed for mover controller **180** and linear rail actuator **725**, and a previously determined response time for the locking mechanism. Using this information, mover controller **180** may compute an expected time delay between when it issues a signal to linear rail actuator **725** indicating that the locking mechanism should engage, and when the locking mechanism actually engages.

During use, mover controller **180** may determine a speed with which the occupant is moving seat bottom **125**, and use extrapolation based on the speed to determine a future point in time at which seat bottom **125** is predicted to achieve preferred longitudinal position (d(pref)). If the current time plus the expected time delay is equal to or within a predetermined tolerance of the future point in time at which seat bottom **125** is predicted to achieve preferred longitudinal position (d(pref)), mover controller **180** issues a signal to linear rail actuator **725**, which powers the locking mechanism as to assume a locked position. By the time the locking mechanism engages, seat bottom **125** should have achieved an position approximately equal to preferred longitudinal position (d(pref)).

As with seat-motion controller **110**, seat-motion controller **710** is illustratively mounted to vehicle floor **135** and is in electrical communication with seat-back sensor **107**, vehicle orientation sensor **109**, and linear position sensor **702** through electrical cabling **155**, as shown in FIG. **9**. However, seat-motion controller **710** may be located in any position within vehicle **143** such that it can be placed in wired or wireless electrical communication with seat-back sensor **107**, vehicle orientation sensor **109**, and linear position sensor **702**.

As with seat-motion controller **110**, seat-motion controller **710** and all its components, including rotation calculator **715**, may be implemented in software, compiled and stored to a memory as object code, and during operation of the seat position sensing system **700**, may be invoked for execution by a processor. In one implementation, the above-described components are implemented as a single system on a chip. The interconnections among the above-described components can be provided through any suitable electronic communication mechanism, such as a communication bus or cabling. In other implementations, the above-described components may be implemented on separate hardware modules and placed in communication with one another through any suitable electronic communication mechanism, such as a communication bus or cabling.

In illustrative embodiments, seat-back sensor **107**, vehicle orientation sensor **109**, and linear position sensor **702** may be coupled with a temperature-sensitive component, such as a thermistor, which enables their respective accelerometers to compensate and correct for output drift or other variations in output accuracy caused by temperature changes.

In illustrative embodiments, vehicle **143** includes mechanisms to cap the speed at which seat back **130** can rotate and/or the speed at which seat foundation **127** can longitudinally move. A speed cap can be beneficial to ensure that position calculator **160** receives a sufficient number of samples as seat back **130** rotates and/or as seat foundation **127** slides. As such, the speed cap may be a function of the sampling rate of position calculator **160**.

As previously explained, during driving conditions, vehicle **143** and its internal components may vibrate. Such vibrations may introduce noise into the outputs of seat-back sensor **107**, vehicle orientation sensor **109**, and linear position sensor **702**. To mitigate the impact of such noise on system accuracy, seat-orientation units **105**, **705** or seat-motion controllers **110**, **710** may include filters or other signal processing components to enhance signal to noise ratios.

Although certain embodiments have been described and illustrated in exemplary forms with a certain degree of particularity, it is noted that the description and illustrations have been made by way of example only. Numerous changes in the details of construction, combination, and arrangement of parts and operations may be made. Accordingly, such changes are intended to be included within the scope of the disclosure.

The invention claimed is:

1. An occupant-support sensing system comprising

an occupant support including a seat bottom adapted to couple to a floor to move back and forth along a longitudinal axis relative to the floor and a seat back coupled to the seat bottom and arranged to extend upwardly away from the seat bottom to pivot about an axis relative to the seat bottom,

a support-orientation unit including a floor-orientation accelerometer coupled to the floor in a fixed position relative to the floor and configured to sense a gravity-based incline angle of the floor and a seat-back accelerometer coupled to the seat back to move therewith relative to the seat bottom and the floor and configured to sense a gravity-based recline angle of the seat back, and

a support-motion controller coupled to the occupant support and the support-orientation unit and configured to calculate a floor-incline angle using data received from the floor-orientation accelerometer, an actual seat-back angle using data received from the seat-back accelerometer, and an adjusted seat-back angle using the floor-incline angle and the actual seat-back angle,

wherein the support-motion controller includes a position calculator configured to calculate the adjusted seat-back angle using the floor-incline angle and the actual seat-back angle and

wherein the position calculator calculates the adjusted seat-back angle by subtracting the floor-incline angle from the actual seat-back angle.

2. The occupant-support sensing system of claim **1**, wherein the support-motion controller further includes a mover controller coupled to the position calculator to receive the actual seat-back angle and a seat-back actuator coupled to the seat back to control movement of the seat back relative to the seat bottom in response to a signal received from the mover controller.

3. The occupant-support sensing system of claim **2**, wherein the seat-back actuator is a motor coupled to the seat back and configured to move the seat back relative to the seat bottom in response the signal received from the mover controller.

4. The occupant-support sensing system of claim **2**, wherein the seat-back actuator is coupled to a seat-back locking mechanism and configured to engage a locking mechanism of the occupant support to block movement of the seat back relative to the seat bottom in response to the signal received from the mover controller.

5. An occupant-support sensing system comprising

an occupant support including a seat bottom adapted to couple to a floor to move back and forth along a longitudinal axis relative to the floor and a seat back coupled to the seat bottom and arranged to extend upwardly away from the seat bottom to pivot about an axis relative to the seat bottom,

a support-orientation unit including a floor-orientation accelerometer coupled to the floor in a fixed position relative to the floor and configured to sense a gravity-based incline angle of the floor and a seat-back accelerometer coupled to the seat back to move therewith relative to the seat bottom and the floor and configured to sense a gravity-based recline angle of the seat back, and

a support-motion controller coupled to the occupant support and the support-orientation unit and configured to calculate a floor-incline angle using data received from the floor-orientation accelerometer, an actual seat-back angle using data received from the seat-back accelerometer, and an adjusted seat-back angle using the floor-incline angle and the actual seat-back angle,

wherein the support-motion controller includes a position calculator configured to calculate the adjusted seat-back angle using the floor-incline angle and the actual seat-back angle and

wherein the support-motion controller is further configured to determine a rotational speed of the seat back relative to the seat bottom and predict a future adjusted seat-back angle using the actual seat-back angle, the floor-incline angle, and the rotational speed of the seat back.

6. The occupant-support sensing system of claim **5**, wherein the support-motion controller includes a mover controller configured to compute an expected time delay between issuing a command to a seat-back actuator included in the support-motion controller and detecting the adjusted seat-back angle matches the future adjusted seat-back angle.

7. The occupant-support sensing system of claim **6**, wherein the mover controller sends the command to the seat-back actuator at the expected time delay to cause the adjusted seat-back angle to match the future adjusted seat-back angle.

8. An occupant-support sensing system comprising

an occupant support including a seat bottom adapted to couple to a floor to move back and forth along a longitudinal axis relative to the floor and a seat back coupled to the seat bottom and arranged to extend upwardly away from the seat bottom to pivot about an axis relative to the seat bottom,

a support-orientation unit including a floor-orientation accelerometer coupled to the floor in a fixed position relative to the floor and configured to sense a gravity-based incline angle of the floor and a seat-back accelerometer coupled to the seat back to move therewith relative to the seat bottom and the floor and configured to sense a gravity-based recline angle of the seat back, and

a support-motion controller coupled to the occupant support and the support-orientation unit and configured to calculate a floor-incline angle using data received from the floor-orientation accelerometer, an actual seat-back angle using data received from the seat-back accelerometer, and an adjusted seat-back angle using the floor-incline angle and the actual seat-back angle,

wherein the seat back includes a backrest coupled to the seat bottom to rotate about the axis relative to the seat bottom and a headrest coupled to the backrest to move therewith and locate the backrest between the headrest and the seat bottom and the seat-back accelerometer is coupled to the backrest between the axis and the headrest.

9. The occupant-support sensing system of claim **8**, wherein the seat-back accelerometer is located nearer to the axis than a midpoint between the axis and the headrest.

10. An occupant-support sensing system comprising

an occupant support including a seat bottom adapted to couple to a floor to move back and forth along a longitudinal axis relative to the floor and a seat back coupled to the seat bottom and arranged to extend upwardly away from the seat bottom to pivot about an axis relative to the seat bottom,

a support-orientation unit including a floor-orientation accelerometer coupled to the floor in a fixed position relative to the floor and configured to sense a gravity-based incline angle of the floor and a seat-back accelerometer coupled to the seat back to move therewith relative to the seat bottom and the floor and configured to sense a gravity-based recline angle of the seat back, and

a support-motion controller coupled to the occupant support and the support-orientation unit and configured to calculate a floor-incline angle using data received from the floor-orientation accelerometer, an actual seat-back angle using data received from the seat-back accelerometer, and an adjusted seat-back angle using the floor-incline angle and the actual seat-back angle,

wherein the support-orientation unit further includes a linear-position accelerometer coupled to the seat bottom to move therewith relative to the floor and configured to sense a gravity-based rotation angle of the linear-position accelerometer relative to the seat bottom.

11. The occupant-support sensing system of claim **10**, wherein the support-motion controller is further configured to calculate a longitudinal position of the seat bottom relative to the floor using the floor-incline angle and the gravity-based rotation angle from the linear-position accelerometer.

12. The occupant-support sensing system of claim **11**, wherein the support-orientation unit further includes a conversion unit coupled to the seat bottom to move therewith and configured to convert back and forth movement of the seat bottom into rotational movement and the linear-position accelerometer coupled to the conversion unit to rotate relative to the seat bottom as the seat bottom moves back and forth along the longitudinal axis.

13. The occupant-support sensing system of claim **12**, wherein the conversion unit includes a roller configured to engage a stationary track included in the occupant support, a rotating shaft coupled to the roller to move therewith, a reduction unit having an input coupled to the rotating shaft to rotate therewith and an output coupled to the linear-position accelerometer to cause the linear-position accelerometer to rotate in response to rotation of the roller.

14. The occupant-support sensing system of claim **11**, wherein the support-motion controller includes a position calculator configured to calculate the adjusted seat-back angle using the floor-incline angle and the actual seat-back angle and the longitudinal position using the floor-incline angle and the gravity-based rotation angle.

15. The occupant-support sensing system of claim **14**, wherein the position calculator calculates the adjusted seat-back angle by subtracting the floor-incline angle from the actual seat-back angle and the longitudinal position by subtracting the floor-incline angle from the gravity-based rotation angle.

16. The occupant-support sensing system of claim **15**, wherein the support-motion controller further includes a mover controller coupled to the position calculator to receive the adjusted seat-back angle and the longitudinal position and a linear-rail actuator coupled to the seat bottom to control movement of the seat bottom relative to the floor in response to a signal received from the mover controller.

17. An occupant-support sensing system comprising

an occupant support including a seat bottom adapted to couple to a floor to move back and forth along a longitudinal axis relative to the floor and a seat back coupled to the seat bottom and arranged to extend upwardly away from the seat bottom to pivot about an axis relative to the seat bottom,

a support-orientation unit including a floor-orientation accelerometer coupled to the floor in a fixed position relative to the floor and configured to measure and output accelerations relative to gravity of the floor and a seat-back accelerometer coupled to the seat back to move therewith and configured to measure and output accelerations relative to gravity of the seat back, and

a support-motion controller coupled to the occupant support and the support-orientation unit and configured to calculate a floor-incline angle using output accelerations of the floor-orientation accelerometer, an actual seat-back angle using output accelerations of the seat-back accelerometer, and an adjusted seat-back angle using the floor-incline angle and the actual seat-back angle.

18. The occupant-support sensing system of claim **17**, wherein the support-orientation unit further includes a linear-position accelerometer coupled to the seat bottom to move therewith relative to the floor and configured to measure and output accelerations relative to gravity of the linear-position accelerometer, the support-motion controller is configured to calculate a rotation amount of the linear-position accelerometer, and the support-motion controller is configured to convert the rotation amount into a longitudinal position of the seat bottom relative to the floor.

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